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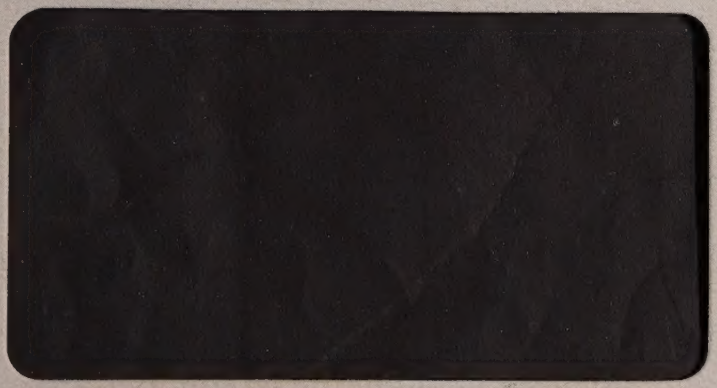
HANDBOOK
OF
OPERATING INSTRUCTIONS



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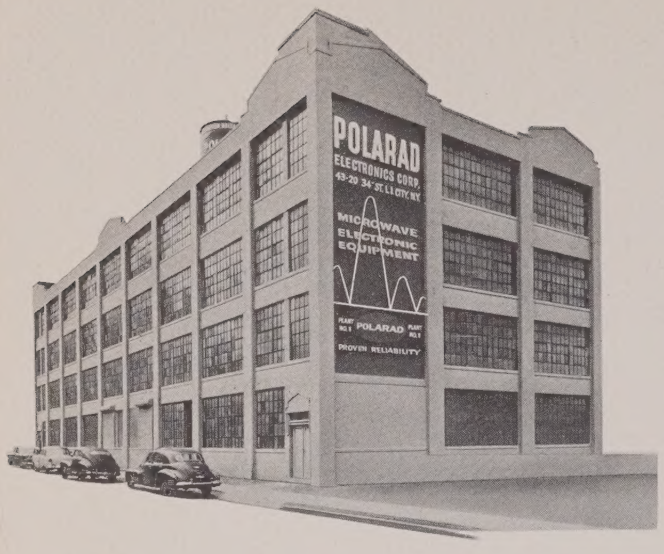

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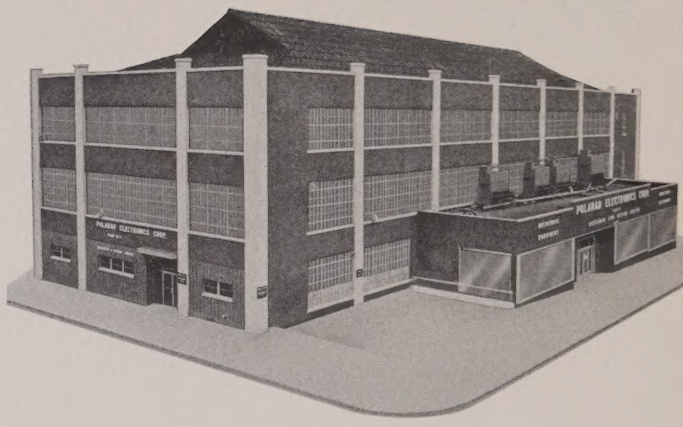

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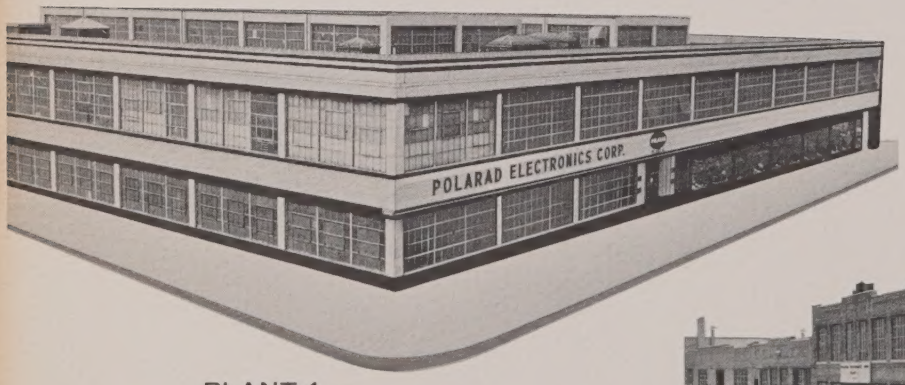

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POLARAD

PROVEN RELIABILITY

INSTRUCTION MANUAL

PRECISION
NOISE GENERATOR
MODEL N-1

POLARAD ELECTRONICS CORPORATION
43-20 34th STREET • LONG ISLAND CITY 1 • NEW YORK, N. Y.

Warranty

Polarad Electronics Corporation warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, fuses or batteries, which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which on our examination shall disclose to our satisfaction to have been thus defective.

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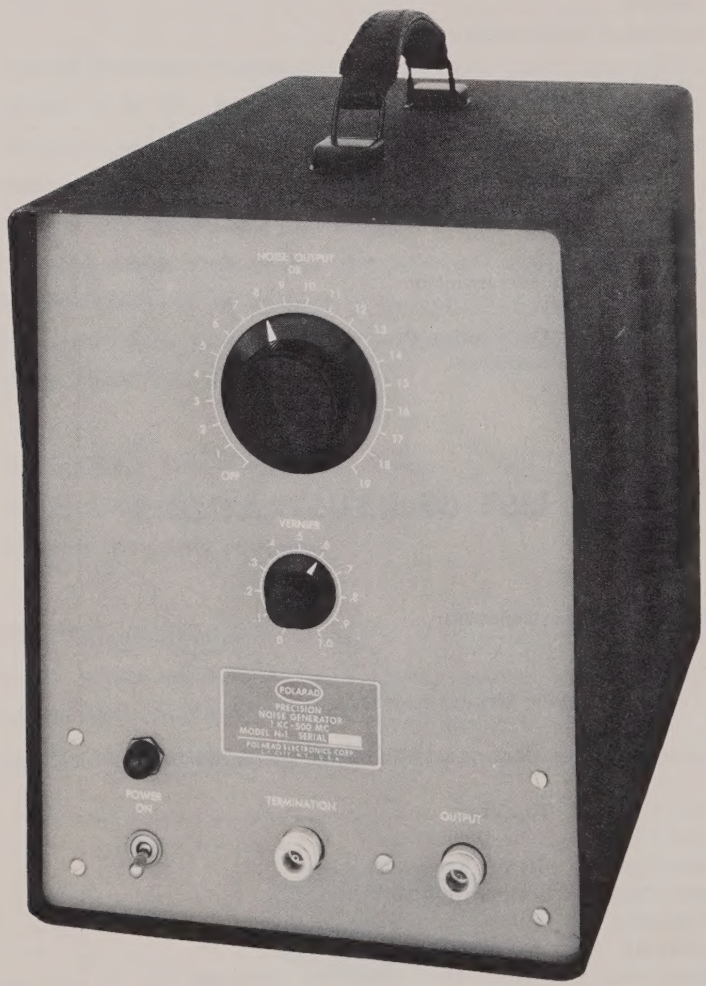

Figure 1-1. Model N-1 Precision Noise Generator

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL

This manual provides information for operating and maintaining Polarad's Model N-1 Precision Noise Generator. These instructions also include theory of operation, trouble shooting procedures, and a complete electrical parts list.

1-2. PURPOSE OF EQUIPMENT

The Model N-1 Precision Noise Generator, shown as figure 1-1, is used to measure noise figures of vacuum-tube amplifiers, transistor amplifiers, receivers, and other devices or networks which operate in the frequency range from 1 kc to 500 mc. The resulting measurements are expressed in "db above thermal noise" at the reference temperature (290°K = 62.6°F).

1-3. GENERAL DESCRIPTION

The unit is small and compact, and has simple controls. Its noise output range is covered in steps of 1 db from 0 to 19 db by means of a rotary attenuator switch on the front panel. An interpolation control, variable between 0 and 1 db, permits fine adjustment of the noise output to the desired fraction of a decibel, and extends the noise range to 20 db. The sum of the values indicated by these two controls is the total noise output.

The instrument is entirely self-contained, and includes well-regulated power supplies. Special provision is made for shielding its temperature-limited, noise generator diodes.

1-4. GENERAL PHYSICAL CHARACTERISTICS

Dimensions	8-1/2 in. wide by 11 in. high by 15 in. deep.
Finish	Green baked enamel.
Weight	24 lbs.

1-5. ACCESSORIES SUPPLIED (Figure 1-2)

50-ohm coaxial termination.
6000 mmf blocking capacitor, coaxial construction.

1-6. GENERAL ELECTRICAL CHARACTERISTICS

Noise Figure Range	1 to 20 db.
Switching Steps	1 db.
Fine Adjust	0 to 1 db interpolation.
Frequency Range	1 kc to 500 mc, with termination of 50 ohms.
Accuracy	±0.25 db.
Output Impedance	50 to 10,000 ohms, depending on termination.
Fuse Ratings	One 3 amps, 125V, 3AG. Two 2 amps, 125V, 3AG.
Input Power Requirements	115/230V, 50 to 60 cps, 130 watts.
Tube Complement	See table 1-1.

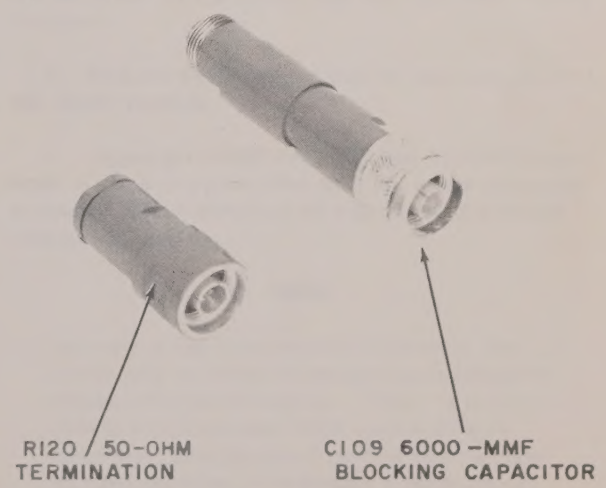

Figure 1-2. Accessories Supplied

TABLE 1-1. TUBE COMPLEMENT

Reference Designation	Type	Function
V101	5Y3	Rectifier, -100 volts regulated B- supply.
V102	6AU5	Pass tube, -100 volts regulated B- supply.
V103	6AN8	D-c amplifier (-100 volts regulated B- supply) and chopper amplifier.
V104	6X4	Rectifier, +100 volts reference supply, +300 volts unregulated B+ supply.
V105	6AQ5	Pass tube, +100 volts reference supply.
V106	6X4	Rectifier, -108 volts reference supply.
V107	12AX7	D-c amplifier, +100 volts reference supply.
V108	0B2	Voltage regulator, -108 volts reference supply.
V109	12AX7	Amplifier
V112	Sylvania 5722	Noise diode.
V113	Sylvania 5722	Noise diode.
V114	Sylvania 5722	Noise diode.
CR101	Sarkes-Tarzian 10LF	Silicon rectifier, diode filament supply.
CR102	Sarkes-Tarzian 10LF	Silicon rectifier, diode filament supply.
Q101	2N456	Filament voltage control amplifier.
Q102	2N456	Filament voltage control amplifier.

SECTION II
OPERATION

2-1. INPUT VOLTAGE

The instrument may be operated on either 115 or 230 volts, 50 to 60 cps, depending upon the position of slide switch S102, located on rear of the chassis. See figure 4-2. For 115-volt operation, S102 places the primary windings of power transformer T101 in parallel across the 115-volt line. In 230-volt operation, the windings are connected in series with each other across the 230-volt line. Normally, switch S102 is set at the factory for 115-volt operation.

2-2. POWER SWITCH

The unit is turned on and off by means of power switch S101, located at the bottom left of the front panel. POWER ON lamp DS101, immediately above the switch, indicates when the power is on.

2-3. MEASUREMENT OF NOISE FIGURE

Noise figure may be defined as the amount of introduced noise required to produce an output 3 db higher than the output when no input signal is applied.* This value is indicated directly by the Model N-1 Precision Noise Generator.

To perform noise figure measurements with the instrument, follow the procedure outlined below. Figure 2-1 shows the test set-up.

a. Procedure for Measuring Noise Figure.

1. Connect a termination to the TERMINATION jack of the Model N-1 having the same value as the input impedance of the device under test. Since an input impedance of 50 ohms is most often encountered, this value of termination is supplied with the instrument. For other values, see paragraph 2-3b.

2. Connect a blocking capacitor to the OUTPUT jack of the noise generator. If the termination is 50-ohms and the frequency used is between 10 and 500 mc the 6000 mmf blocking capacitor can be used. For other frequencies, see table below. For other termination impedances, see paragraph 2-3c.

NOTE

Both a termination and a blocking capacitor must be used for all measurements.

TABLE 2-1. RECOMMENDED VALUES OF BLOCKING CAPACITOR (1 KC - 500 MC)

Value of Blocking Capacitor	Frequency Range
6000 uuf	10 mc - 500 mc
0.05 uf	1 mc - 10 mc
0.5 uf	100 kc - 1 mc
5 uf	10 kc - 100 kc
50 uf	1 kc - 10 kc

NOTE: All values suggested for use with 50-ohm termination.

3. Using shielded cable, connect the input of the device under test to the output of the blocking capacitor.

4. Connect a meter of adequate sensitivity to the output of the device under test.

NOTE

If a meter which reads db directly is not available, a voltage measuring device can be used.

5. Set the NOISE OUTPUT control of the noise generator to the OFF position, and the VERNIER control to zero.

6. With the device under test in operation, record the meter reading.

7. Adjust the NOISE OUTPUT and VERNIER controls of the noise generator until the meter indicates a reading that is exactly 3 db higher than the output obtained in step 6.

NOTE

Because of the time constants involved, the meter may not show instantaneous response to changes of control settings. Thus, it is advisable to wait a moment after each setting to make sure that the meter pointer has reached its final position. If a voltage measuring device has been used, multiply the meter reading of step 6 by 1.414 to obtain meter reading for step 7.

* Note: This definition is equivalent to the more often cited definition:

$$F = \frac{S_I/N_I}{S_O/N_O}$$

Where: S_I/N_I = Available signal-to-noise power ratio at input.

S_O/N_O = Available signal-to-noise power ratio at output.

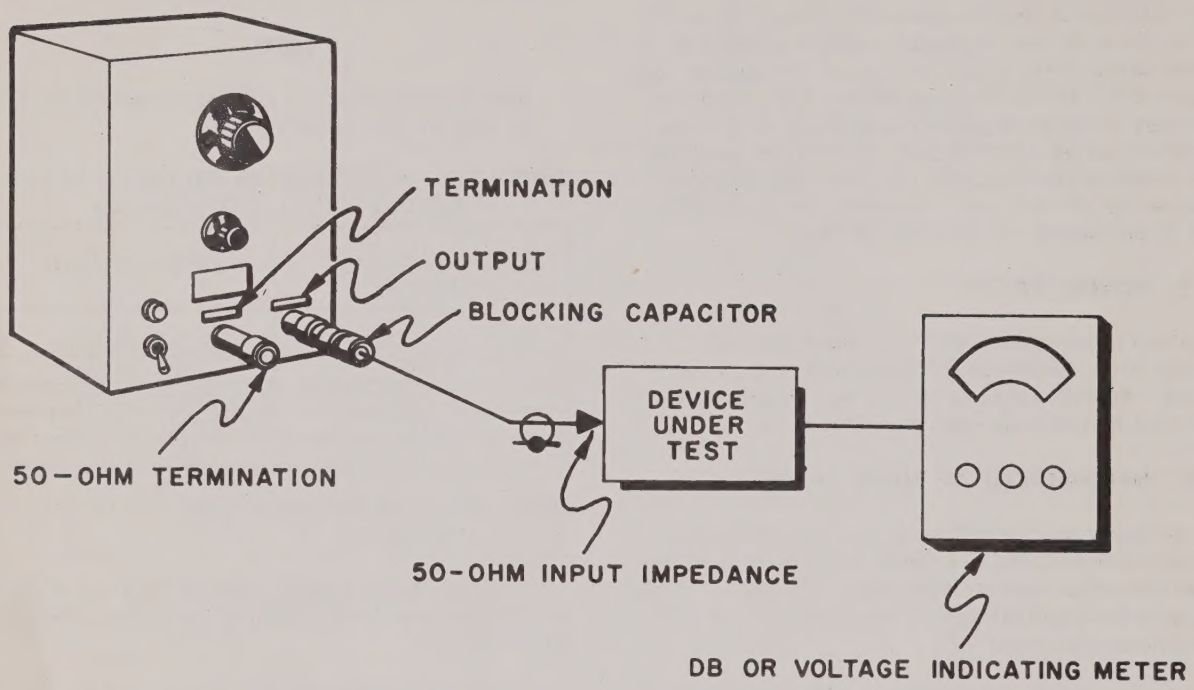

Figure 2-1. Test Set-Up for Noise Figure Measurement

8. Read the output level by adding the indications of the NOISE OUTPUT and VERNIER controls. The sum is the noise figure (in decibels) of the device under test. Normal temperature variation has a negligible affect on the accuracy of the Model N-1.

b. Construction of Other Terminations. For accurate measurements of a noise figure, it is necessary that the termination have the same impedance as the input of the network under test. If the required termination value is other than 50 ohms, it will be necessary to construct a special termination.

For terminations up to 200 ohms, it is possible to modify the 50-ohm termination supplied with the instrument by replacing the 50-ohm disc resistor in the termination with the same type of disc resistor having the required value. These disc resistors are available in values up to 200 ohms from Mepco, Incorporated, Morristown, N.J., and are known as Type C500D.

For terminations between 200 and 10,000 ohms, an Allen Bradley, 1/2 watt, composition resistor mounted in a Type N connector may be used. It should be noted, however, that when terminations greater than 50 ohms are used, the high-frequency limit of noise output is reduced, because the upper frequency limit is a function of the termination value. Thus, the upper limit will not be as high as 500 mc.

c. Use of Other Blocking Capacitors. The blocking capacitor supplied is 6000 mmf, and can be used with a 50-ohm termination for frequencies between 10 and 500 mc. For operation at lower frequencies a larger blocking capacitor is required, but coaxial construction is not necessary. Therefore, conventional capacitors may be used. Typical values that can be used with a 50-ohm termination at lower frequencies are given in table 2-1. For higher values of termination, proportionally lower values of blocking capacitor should be used. The value must be chosen such that the capacitive reactance is very much lower than the termination impedance at the frequency of operation. The standard formula for calculating capacitive reactance is used in determining the value:

$$X_C = \frac{1}{2\pi f C}$$

where: X_C = Capacitive reactance (ohms)

π = 3.1416

f = Frequency of operation (cps)

C = Chosen value of capacitance (farads)

SECTION III
PRINCIPLES OF OPERATION

NOTE

All references are made to the schematic diagram of figure 4-7.

3-1. NOISE DIODES

Three temperature-limited noise diodes, V112, V113, V114, are connected in parallel to generate the required noise output. The level of noise output is governed by the voltage applied to the diode filaments, since the filament-to-plate currents (and hence, the noise output) are determined by the voltage on the filaments when the plate voltage is constant. The three diode filaments are connected in series with each other.

Diode capacitances are disposed along a three-section, low-pass filter which allows a bandwidth up to 500 megacycles. The upper frequency limit of operation is determined by the transit time of the electron beam in the noise diodes and the cutoff frequency of the low-pass filter. The cutoff frequency of the filter was designed to be approximately the same as the frequency at which transit time effects start to occur. Ferrite beads FE101 through FE104 filter out unwanted rf signals from the diode filament circuit. Capacitors C122 through C130 bypass unwanted signals from the diode filaments to ground.

3-2. FEEDBACK CIRCUIT

Noise output is accurately maintained at the set level by a feedback circuit, shown in the simplified block diagram of figure 3-1. A portion of the output signal is fed back through resistors R123 and R137 to the output of NOISE OUTPUT control attenuator AT101, where it is added to a predetermined portion of the +100 volts d-c reference voltage.

Chopper CH101A mechanically interrupts this d-c signal and converts it into a square wave which is then applied to the input of high-gain amplifier V109, a twin-triode with both stages connected in cascade.

The output of this amplifier is further amplified by V103B, the triode section of a triode-pentode, and is transformer-coupled to the transistorized, filament-voltage control amplifiers, Q101 and Q102. Before reaching the transistors, the signal is reconverted from square wave to dc by chopper CH101B, which is mechanically synchronized with chopper CH101A. As the result of this conversion-and reconversion process, a very stable high-gain amplifier is obtained which is sensitive to the slightest error voltages occurring across the termination. Compensating adjustments in filament voltage are made by power transistors Q101 and Q102 so that the noise output is accurately maintained at the level set by

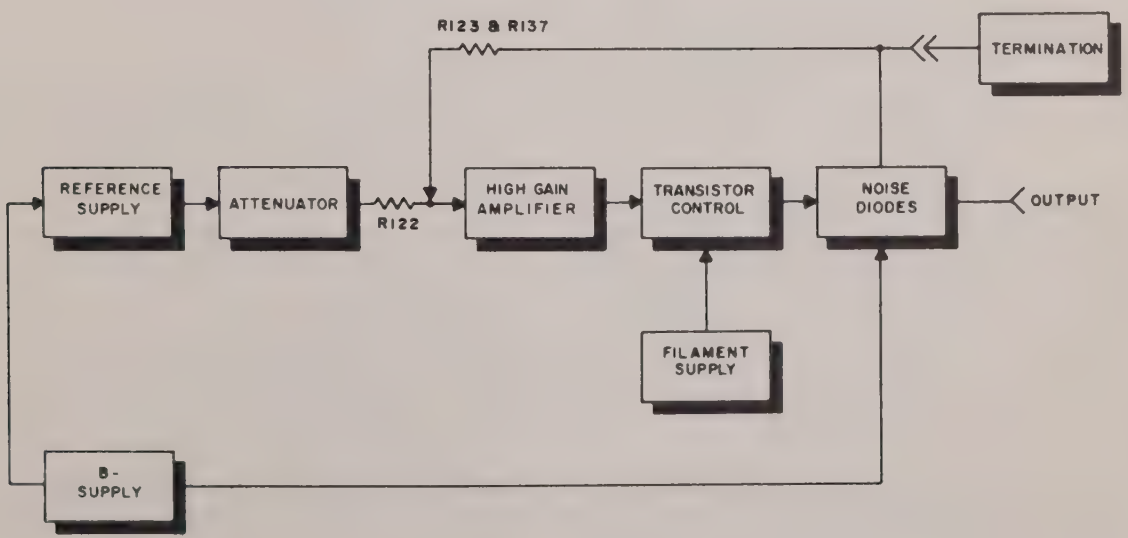

Figure 3-1. Model N-1 Precision Noise Generator, Simplified Block Diagram

the front-panel controls. Q102 is in series with the diode filaments and controls the amount of current flowing through them. In this way, it controls the filament voltages and hence, noise output. Its action is, in turn, governed by transistor amplifier Q101, which is indirectly controlled by the setting of attenuator AT101.

3-3. POWER SUPPLIES

a. +100 Volt Regulated Reference Supply. The +100 volt reference supply provides the stable reference voltage required across the series combination of VERNIER control R119, resistor R121, and attenuator AT101. It also provides B+ voltage for amplifier V103B, and screen voltage for V102.

Basically, this supply consists of rectifier V104, pass tube V105, twin-triode amplifier V107, and associated circuitry. A-c input to the rectifier tube is obtained from one of the center-tapped secondary windings of transformer T101 (taps 8 and 10). The output of the rectifier passes through pass tube V105 to the load. When small changes in input voltage or load current occur, the plate-to-cathode resistance of the regulator tube is automatically adjusted by the action of sensitive amplifier V107 so as to maintain a practically constant output voltage across the load.

Adjustment of potentiometer R110 on the rear of the chassis (figure 4-2) establishes the normal resistance of pass tube V105; therefore, this control is used to set the value of load voltage which the regulator is to maintain.

b. -108 Volt Reference Supply. The -108 volt reference supply provides negative reference and bias voltage for the +100 volt- and -100 volt power supplies. It includes half-wave rectifier V106, voltage-regulator tube V108, and a conventional r-c filter circuit to smooth out ripple.

A-c voltage from tap 10 of transformer T101 is applied between the cathode of V106 and chassis ground. The negative d-c output voltage is taken off the plates of V106. Filtering is provided by an r-c circuit consisting of R112 and C105, followed by a second-stage filter consisting of R113, C106, and R114.

The filtered output is applied across neon-glow tube V108, which acts as a voltage regulator.

c. -100 Volt Regulated B- Supply. This supply provides a stable B- output for the noise diodes. The output voltage is sufficiently high to ensure that temperature-limited conditions are maintained over the full range of diode current.

A negative voltage is used on the diodes' filaments so that the plates can be kept at the approximate voltage level of chassis ground. This arrangement is desirable in order to eliminate the possibility of shock hazards, because direct connections to the plates are available through the front panel OUTPUT and TERMINATION jacks.

The regulated B- supply consists basically of rectifier V101, pass tube V102, and d-c amplifier V103A. A-c input is obtained from taps 5 and 7 of power transformer T101. Tap 6, the center-tap of the winding, is the output of this negative supply.

The circuit is similar to the +100-volt regulated supply circuit in that it uses a full-wave rectifier, a series regulator tube, and a sensitive amplifier which automatically adjusts the plate-to-cathode resistance of the regulator tube in order to maintain a practically constant output voltage.

The basic difference between the two circuits is that in the B+ reference circuit, the center-tap (pin 6) of the transformer secondary winding is grounded and the output is taken from the cathode of the pass tube, whereas in the B-supply the cathode of the pass tube is grounded while the output is taken from the center-tap of the transformer secondary winding. Another minor difference is that a single stage, high-gain pentode is used as the amplifier in the B- supply, whereas a twin-triode amplifier is used in the positive reference supply.

d. +300 Volt Unregulated Supply. The +300 volt unregulated supply provides B+ voltage for tubes V103A and V109. It consists of rectifier V104 (which also serves as rectifier for the +100 volt regulated reference supply), resistor R115, and filter capacitors C108A and C108C.

e. A-c Filaments Supply. Taps 16 and 17 of power transformer T101 provide 6.3 volts ac for the filaments of V102, V103, V104, V105, V106, V107, V109, and for the operation of chopper CH101 and pilot light DS101.

A separate secondary winding, taps 11 and 12, provides 5.0 volts ac for the filament of rectifier V101.

f. Diode-Filaments Supply. A diode-filament supply of approximately 20 volts is required, since the filaments of V112, V113, and V114 are connected in series. A-c input voltage is taken from one of the center-tapped secondaries of transformer T101. Two silicon diodes are employed in a conventional full-wave rectifier circuit. The rectifier plates are connected to transformer taps 13 and 15, respectively, while the cathodes are connected together. The output is taken across the cathodes and the center tap, and is filtered by smoothing capacitor C112. Fuse F103 protects against short circuits and overloads. The load consists of the three diode filaments and control transistor Q102, all in series. The supply is negatively referenced at -100 volts.

SECTION IV
MAINTENANCE

4-1. TROUBLE-SHOOTING

In the event that the equipment does not operate after a reasonable period of use, the most probable cause is tube failure. In order to check and replace the tubes it is necessary to remove the chassis from the case by unscrewing the two large speed-nut screws at the rear of the instrument.

Before removing the case, however, it is advisable to look for some of the immediately obvious other causes mentioned in the Trouble-Shooting Chart (table 4-1), such as defective power cord or plug, defective termination, blown fuses, etc.

If none of these causes is apparent, inspect the tubes, noting if all are lit. In particular, observe noise diodes V112, V113 and V114. Since the filaments of all three diodes are connected in series, the failure of one will prevent all three from lighting. Also, if protective fuse F103 has "blown", the diode filaments cannot light. Use a tube tester to check suspected tubes, or replace them by substituting a like tube that is known to be in good condition.

If, after checking, all the tubes are found to be satisfactory and the equipment still does not operate, localize the trouble as discussed in the following paragraph.

TABLE 4-1. TROUBLE-SHOOTING CHART

Symptom	Probable Cause
1. Equipment does not operate; pilot light does not light.	Defective a-c line cord or plug. Blown fuse F101 or F102.
2. Equipment does not operate; pilot bulb lights.	Blown fuse F103. Defective filament in one of noise diodes, V112, V113, V114. Defective vacuum tube. No termination or defective termination.
3. Pilot bulb does not light; equipment appears to function normally.	Defective pilot lamp.
4. Equipment does not operate on 115-volts; pilot bulb is very dim.	Switch S102 is in the 230 VOLTS position instead of the 115 VOLTS position.
5. Full output is not exactly -5.0 volts.	+100 volts reference supply is improperly regulated. See paragraph 4-4 for correction.
6. Output does not increase or decrease in steps of exactly 1 db.	Defective attenuator AT101. See paragraph 4-5.

4-2. TROUBLE LOCALIZATION AND ISOLATION

Using as references the schematic of figure 4-7 and table 4-2, "Table of Operating Voltages," begin a systematic check of each stage, starting with the power supply circuits. A vacuum-tube voltmeter is preferred for all voltage measurements, but it is possible to use a volt-ohmmeter for those measurements not indicated by an asterisk in table 4-2. The NOISE OUTPUT and VERNIER controls of the noise generator should be set at 10 db while performing all measurements so that results can be compared with the data of table 4-2. Such a comparison should indicate very quickly if a stage or circuit is functioning correctly.

Other check points, in addition to those given in table 4-2, are as follows:

There should be an output of approximately 15 to 20 volts dc across capacitor C112 in the diode-filament supply circuit. (Be careful to observe the polarity shown in figure 4-7 when connecting the meter.)

Between the variable arm of attenuator AT101 and chassis ground there should be a voltage of 0 to +5 volts dc. This voltage should vary from one limit to the other as the attenuator control is varied from 0 to 19 db.

At pin 3 of chopper CH101A there should be a low amplitude square wave. On the grid of V103B (pin 2) there should be an amplified square wave. At pin 6 of chopper CH101B the square wave should be rectified to dc.

Across capacitors C119 and C132 there should be a

TABLE 4-2. OPERATING VOLTAGES

Socket No.	Plate			Screen			Control Grid			Cathode			Filaments		
	Pin	Volts	Ohms	Pin	Volts	Ohms	Pin	Volts	Ohms	Pin	Volts	Ohms	Pin	Volts	Ohms
XV101	4 6	220AC 220AC	∞ ∞										2 8	190 190	∞ ∞
XV102	5	190	∞	8	100	10K	1	-19*	∞	3	0	0			
XV103A	6	-19	∞	7	0	0	8	-111*	420K	9	-108	∞			
XV103B	1	100	∞				2	8.9*	1 MEG	3	0	0			
XV104	1 6	225AC 225AC	110 110							7	305	∞			
XV105	5	305	∞	6	305	∞	7	83*	∞	2	100	10K			
XV106	1 6	-210 -210	∞ ∞							7	225AC	110			
XV107	1 6	83* 51*	∞ 110K				2 7	50* -.25*	77K 580K	3 8	51* 0	110K 0			
XV108	1 5	0	0							2 4 7	-108	260K			
XV109	1 6	78* 92*	∞ ∞				2 7	-1* -.8*	∞ ∞	3 8	0 0	0 0			
XV112	1 6	.5	50										3 4	-112 -108	
XV113	1 6	.5	50										3 4	-116 -112	
XV114	1 6	.5	50										3 4	-119 -116	
	Emitter			Base			Collector								
Q101	119		∞	119		∞	128		∞						
Q102	119		∞	119		∞	128		∞						

* Voltage reading taken with VTVM.

All readings taken with NOISE OUTPUT controls set at 10 db. - All voltages dc, unless otherwise specified.

d-c voltage which varies according to the setting of attenuator AT101. (Be careful to observe the polarities shown in figure 4-7 when connecting the meter.)

Obviously, if there is a discrepancy at any of the check points, the trouble is in the preceding stage or in the local area of the check point.

4-3. GENERAL MAINTENANCE

Other than normal care and periodic inspection, the Model N-1 Precision Noise Generator requires little routine maintenance. However, its accuracy should be carefully checked from time to time using the procedure outlined below. In particular, it is recommended that such checks be performed each time that tubes are replaced, especially when power supply tubes such as V105 are replaced. If necessary, the instrument should be recalibrated as outlined below.

4-4. ACCURACY CHECK AND CALIBRATION PROCEDURE

1. Connect the 50-ohm termination to the TERMINATION jack.

2. Connect the positive probe of an accurately calibrated d-c meter* to chassis ground.

3. Connect the negative probe of the d-c meter directly to the OUTPUT jack. A blocking capacitor should not be used.

4. Set the N-1 Generator for an output of 20 db (maximum output).

5. Measure the output on the d-c meter. If the generator is accurately calibrated, the meter will read exactly 5.0 volts (actually -5.0 volts).

6. If the meter does not read exactly -5.0 volts, adjust potentiometer R110, located at the rear of the instrument (figure 4-2), until it reads exactly -5.0 volts. Because of the time constants involved, it is advisable to wait a few moments after each adjustment of R110 to make sure that the meter pointer has reached its final position.

7. Check attenuator accuracy.

4-5. CHECKING ATTENUATOR ACCURACY

Once the instrument has been accurately calibrated following the procedure outlined above, check the accuracy of the attenuator control by switching from 20 db down to 1 db, in steps of 1 db, and comparing meter readings with the data given in table 4-3. If the results are not within 0.25 db of the given data, AT101 should be replaced.

* **NOTE:** The accuracy of calibration of the Model N-1 Precision Noise Generator depends upon the accuracy of the meter used. Thus, it is mandatory that the test meter be accurately calibrated.

TABLE 4-3. DATA FOR CHECKING ATTENUATOR ACCURACY

NOISE OUTPUT DB	METER READING VOLTS DC
20	-5.00
19	-3.97
18	-3.16
17	-2.51
16	-1.99
15	-1.58
14	-1.26
13	-1.00
12	-0.79
11	-0.63
10	-0.50
9	-0.397
8	-0.316
7	-0.251
6	-0.199
5	-0.158
4	-0.126
3	-0.100
2	-0.079
1	-0.063

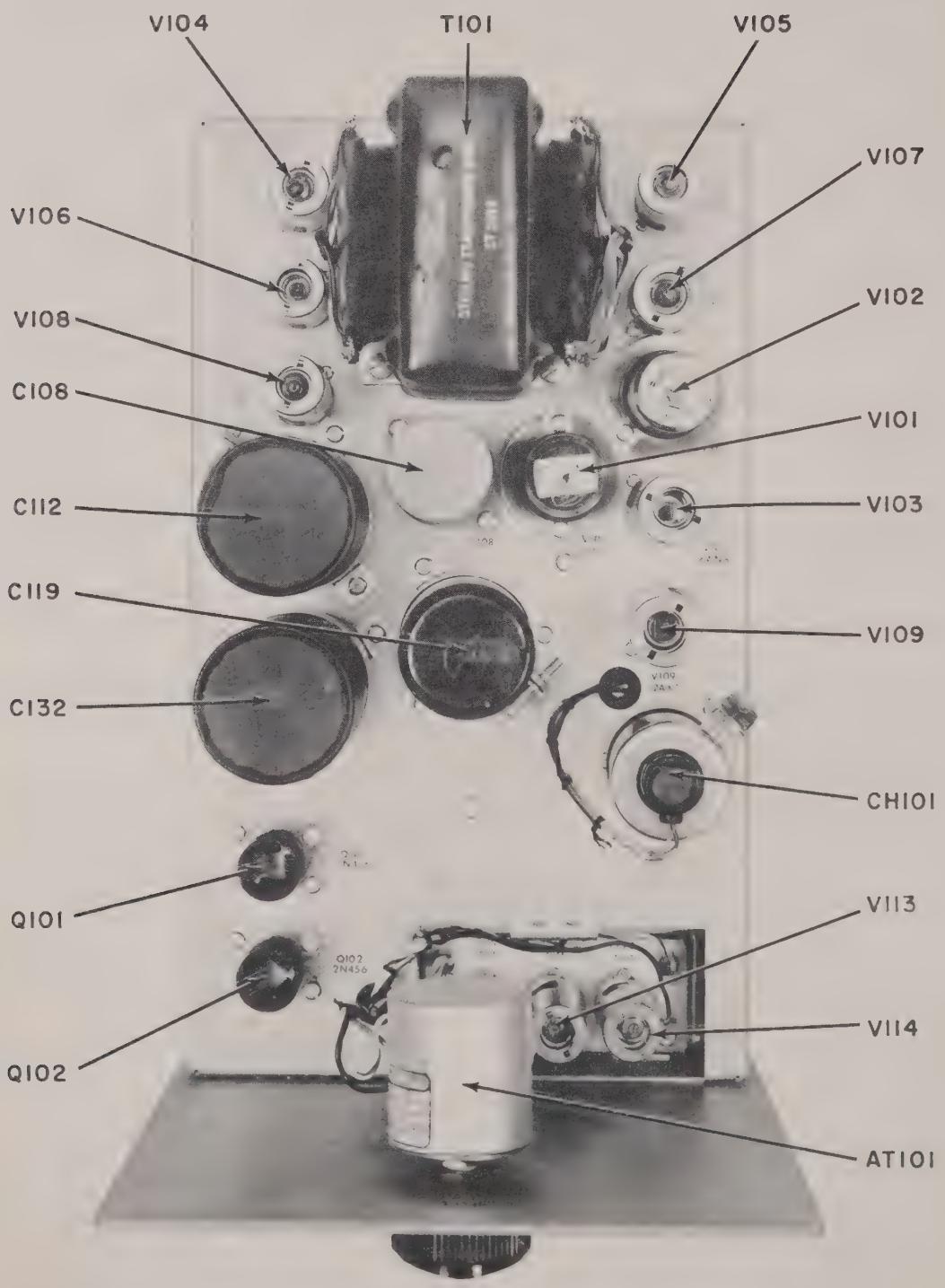

Figure 4-1. Noise Generator Chassis, Top View

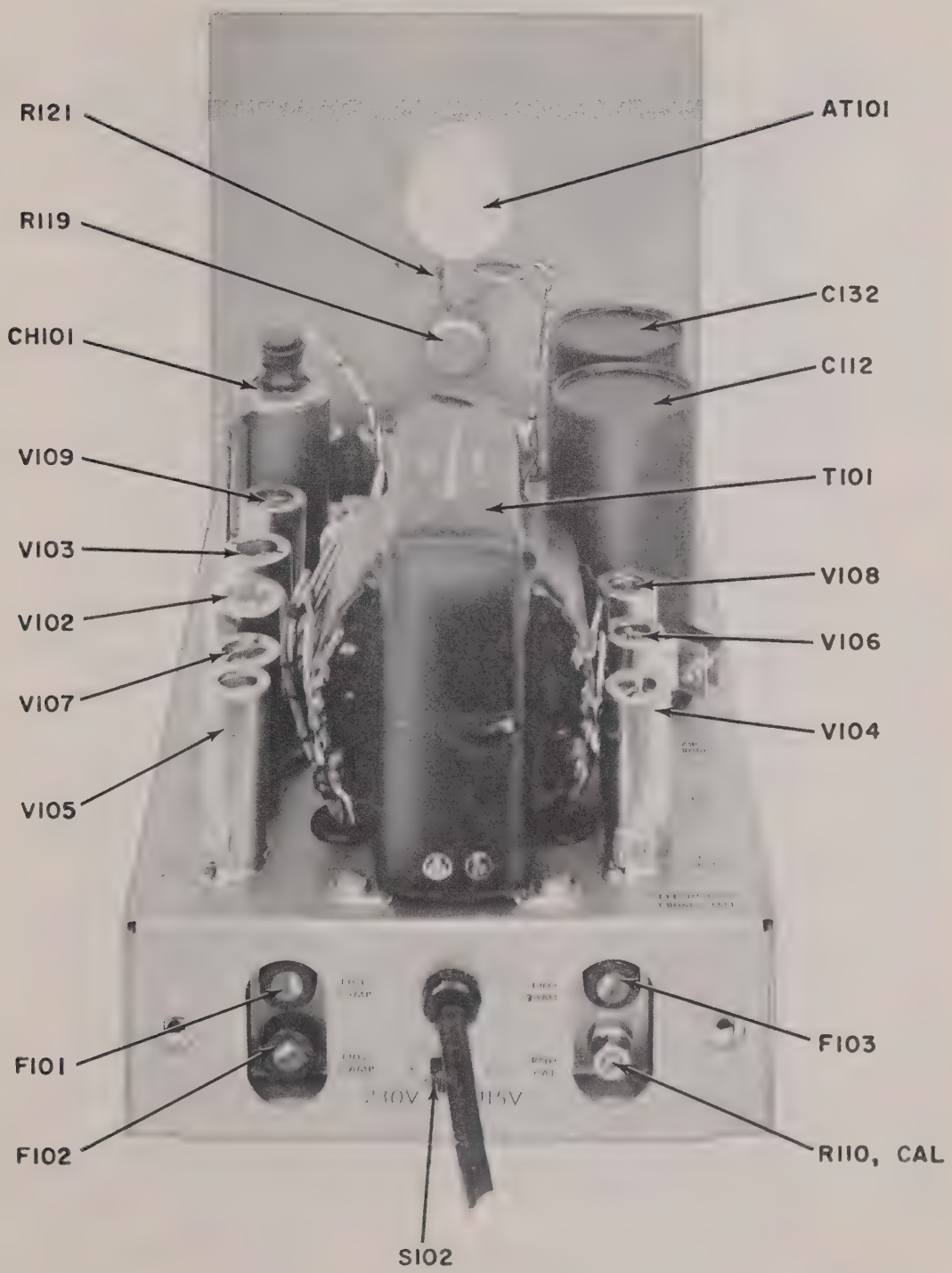

Figure 4-2. Noise Generator Chassis, Rear View

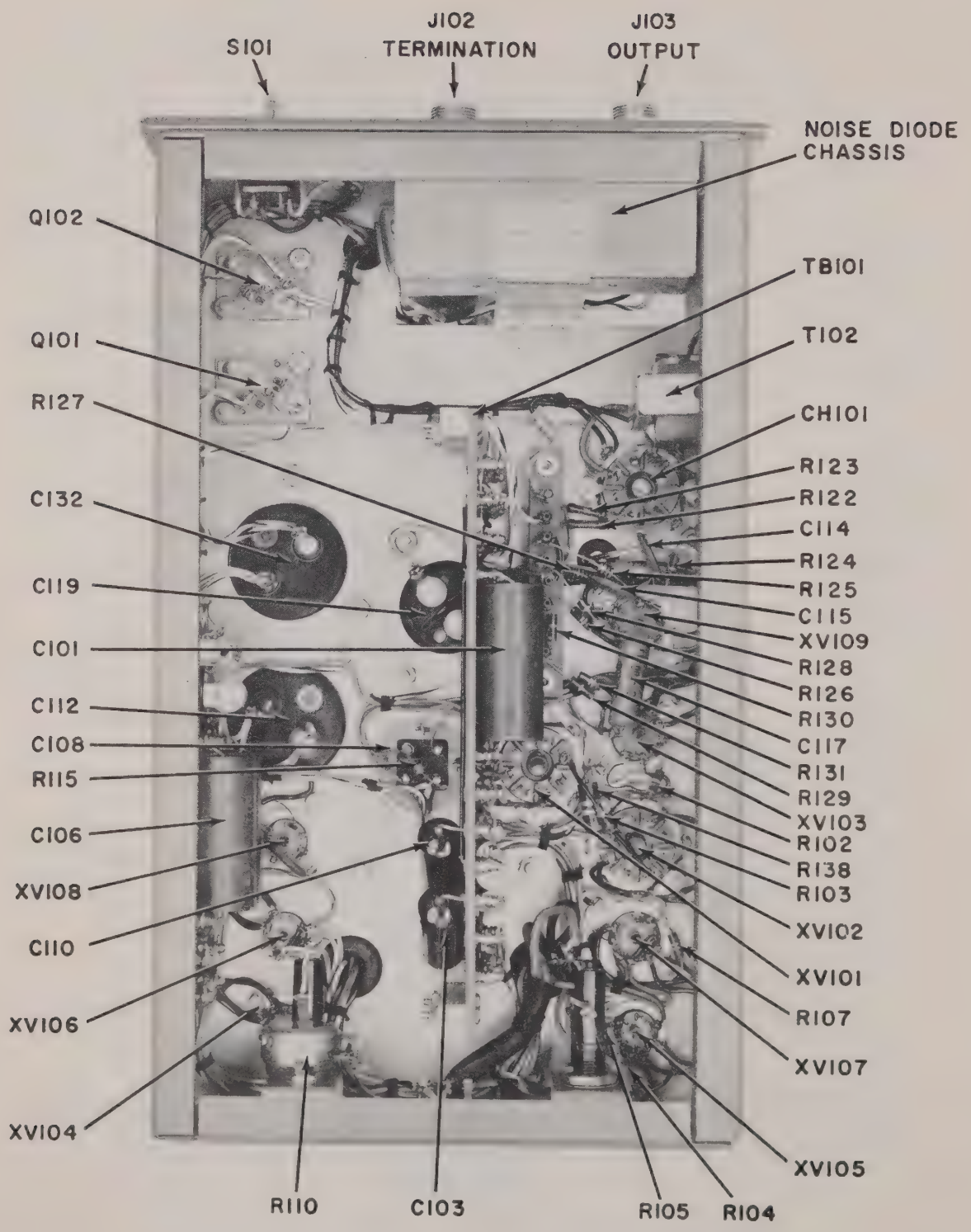

Figure 4-3. Noise Generator Chassis, Bottom View

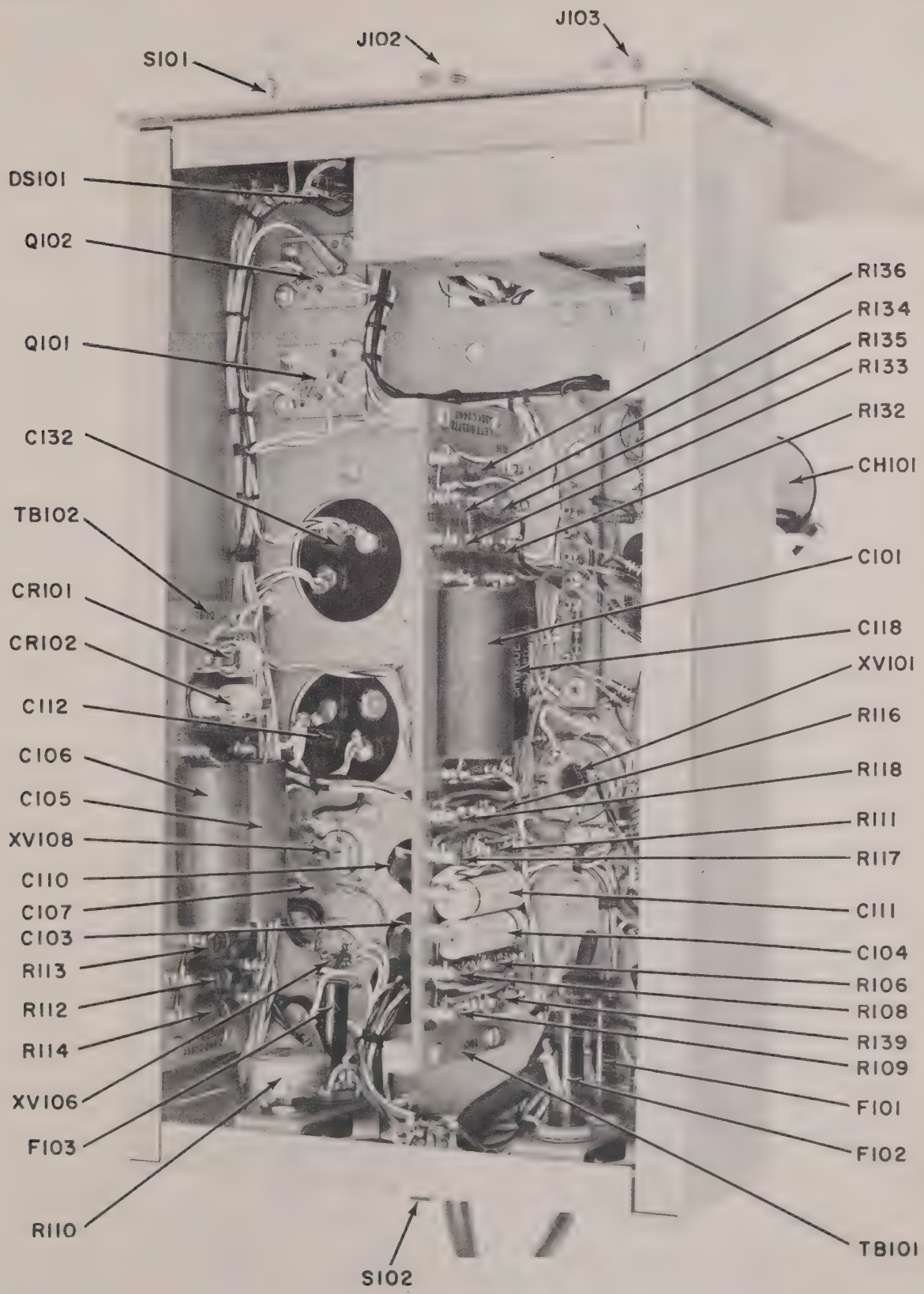

Figure 4-4. Noise Generator Chassis, Bottom Oblique View

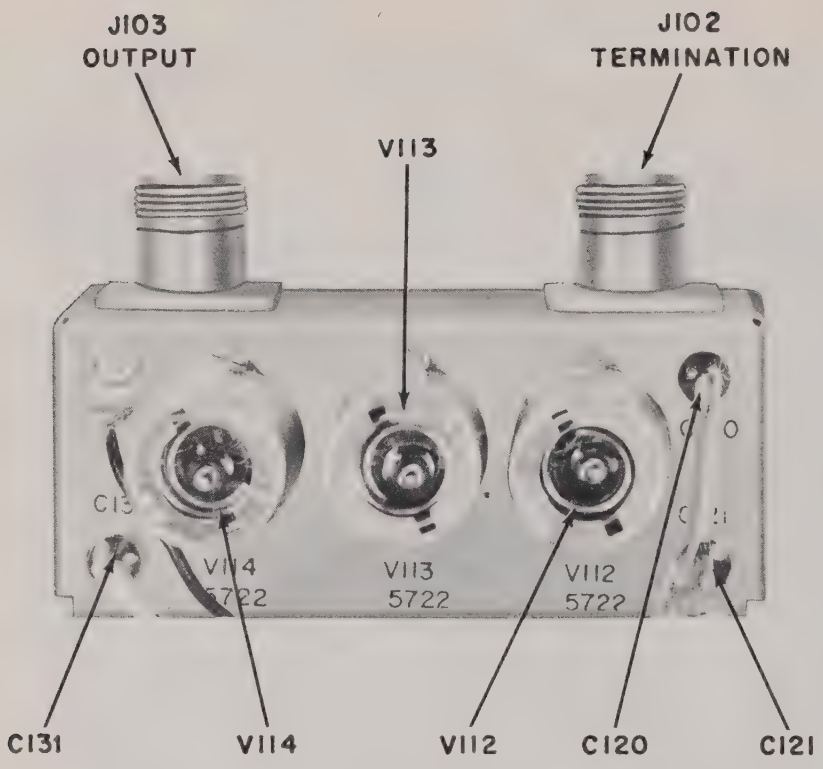

Figure 4-5. Noise Diode Chassis, Top View

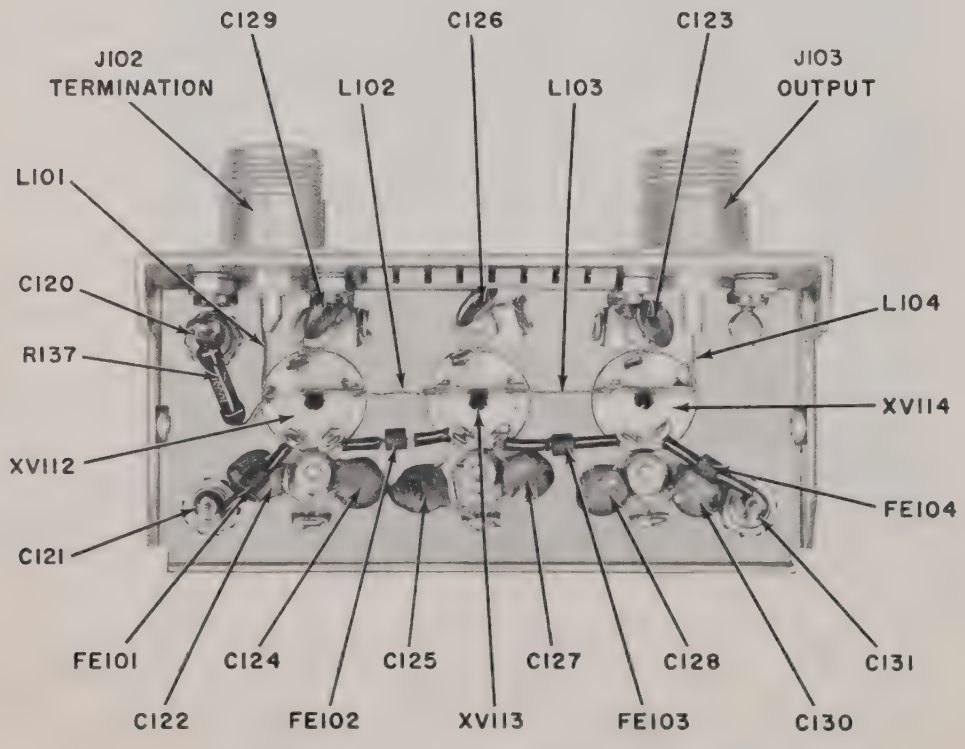

Figure 4-6. Noise Diode Chassis, Bottom View

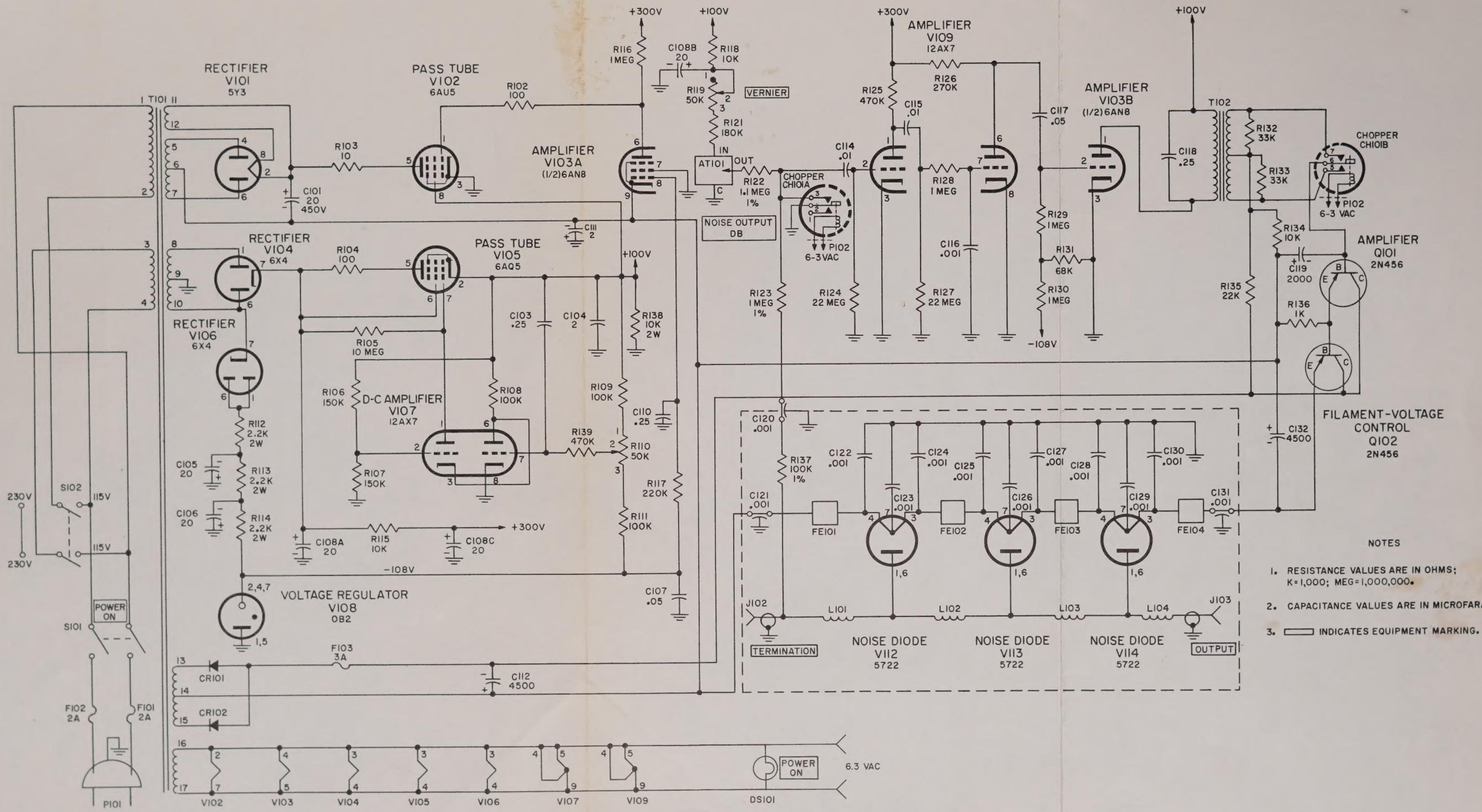

Figure 4-7. Precision Noise Generator, Model N-1, Schematic Diagram

SECTION V
PARTS LIST

5-1. General.

This parts list describes all the electrical parts used in this equipment. The items are listed by schematic reference designation. When a standard part is utilized the number does not appear in the part number column. When a part is available only from the Polarad Electronics Corporation, the part number is listed.

REFERENCE DESIGNATION	DESCRIPTION	POLARAD PART NO.
AT101	ATTENUATOR	A124863
C101	CAPACITOR, Fixed, Electrolytic, 20 uf, 450 wvdc	
C102	Not Used	
C103	CAPACITOR, Fixed, Paper Dielectric; .25 uf, 200 wvdc	
C104	CAPACITOR, Fixed, Electrolytic; 2 uf, 450 wvdc	
C105, C106	Same as C101	
C107	CAPACITOR, Fixed, Ceramic Dielectric; .05 uf, 600 wvdc, guaranteed minimum value	
C108	CAPACITOR, Fixed, Electrolytic; 20-20-20 uf, 450 wvdc	
C109	CAPACITOR, Fixed, Paper Dielectric; 6000 uf	
C110	Same as C103	
C111	Same as C104	
C112	CAPACITOR, Fixed, Electrolytic; 4500 uf, 35 wvdc	
C113	Not Used	
C114, C115	CAPACITOR, Fixed, Ceramic Dielectric; .01 uf, 1000 wvdc, disc type	
C116	CAPACITOR, Fixed, Ceramic Dielectric; .001 uf, ±20%, disc type	
C117	CAPACITOR, Fixed, Paper Dielectric; .05 uf, 200 wvdc	
C118	Same as C103	
C119	CAPACITOR, Fixed, Electrolytic; 2000 uf, 25 wvdc	
C120, C121	CAPACITOR, Fixed, Ceramic Dielectric; .001 uf, 500 wvdc, ±20%, feed thru type	
C122 thru C130	Same as C116	
C131	Same as C120	
C132	Same as C112	
CH101	CHOPPER, dpdt, 60 cycle, make-before-break, hermetically sealed	
CR101, CR102	SEMICONDUCTOR DEVICE, Diode; Sarkes-Tarzian Type 10LF	
DS101	LAMP, Incandescent; 6 v, .2 amps	
F101, F102	FUSE, 2 amps, 125 v, 3 AG, SLO-BLO	
F103	FUSE, 3 amps, 125 v, 3 AG, SLO-BLO	
FE101 thru FE104	BEAD, Ferrite	A115516
J101	Not Used	
J102, J103	CONNECTOR, Receptacle, Electrical	A123521
L101 thru L104	INDUCTANCE, For Reference Only	
Q101, Q102	TRANSISTOR, 2N456	
P101	CONNECTOR, Plug, Electrical; 3 contacts w/gnd, nickel plated finish	
P102	CONNECTOR, Plug, Electrical; 3 contacts, rt angle shape	
R101	Not Used	
R102	RESISTOR, Fixed, Composition; 100 ohms, ±10%, 1/2 w	
R103	RESISTOR, Fixed, Composition; 10 ohms, ±10%, 1/2 w	
R104	Same as R102	
R105	RESISTOR, Fixed, Composition; 10 megohms, ±10%, 1/2 w	
R106, R107	RESISTOR, Fixed, Composition; 150,000 ohms, ±10%, 1/2 w	
R108, R109	RESISTOR, Fixed, Composition; 100,000 ohms, ±10%, 1/2 w	
R110	RESISTOR, Variable	B517853

REFERENCE DESIGNATION	DESCRIPTION	POLARAD PART NO.
R111	Same as R108	
R112 thru R114	RESISTOR, Fixed, Composition; 2,200 ohms, ±10%, 2 w	
R115	RESISTOR, Fixed, Composition; 10,000 ohms, ±10%, 1/2 w	
R116	RESISTOR, Fixed, Composition; 1 megohm, ±10%, 1/2 w	
R117	RESISTOR, Fixed, Composition; 220,000 ohms, ±10%, 1/2 w	
R118	Same as R115	
R119	RESISTOR, Variable	A124862
R120	RESISTOR, Disc Type	A123765
R121	RESISTOR, Fixed, Composition; 180,000 ohms, ±10%, 1/2 w	
R122	RESISTOR, Fixed, Composition; 1.1 megohms, ±1%, 1/2 w	
R123	RESISTOR, Fixed, Composition; 1 megohm, ±1%, 1/2 w	
R124	RESISTOR, Fixed, Composition; 22 megohms, ±10%, 1/2 w	
R125	RESISTOR, Fixed, Composition; 470,000 ohms, ±10%, 1/2 w	
R126	RESISTOR, Fixed, Composition; 270,000 ohms, ±10%, 1/2 w	
R127	Same as R124	
R128 thru R130	Same as R116	
R131	RESISTOR, Fixed, Composition; 68,000 ohms, ±10%, 1/2 w	
R132, R133	RESISTOR, Fixed, Composition; 33,000 ohms, ±10%, 1/2 w	
R134	Same as R115	
R135	RESISTOR, Fixed, Composition; 22,000 ohms, ±10%, 1/2 w	
R136	RESISTOR, Fixed, Composition; 1,000 ohms, ±10%, 1/2 w	
R137	RESISTOR, Fixed, Composition; 100,000 ohms, ±1%, 1/2 w	
R138	RESISTOR, Fixed, Composition; 10,000 ohms, ±10%, 2 w	
R139	Same as R125	
S101	SWITCH, Toggle; dpst	
S102	SWITCH, Slide; dpdt	
T101	TRANSFORMER, Power, Step-up, Step-down	B119033
T102	TRANSFORMER, Interstage; turns ration 1:2, 10 ma, Stancor No. A-52-C	
V101	ELECTRON TUBE; 5Y3	
V102	ELECTRON TUBE; 6AU5	
V103	ELECTRON TUBE; 6AN8	
V104	ELECTRON TUBE; 6X4	
V105	ELECTRON TUBE; 6AQ5	
V106	Same as V104	
V107	ELECTRON TUBE; 12AX7	
V108	ELECTRON TUBE; 0B2	
V109	Same as V107	
V110, V111	Not Used	
V112 thru V114	ELECTRON TUBE; 5722